PROGRESS REPORT NO. 20

NASA ORDER NO. R-93

THE PROBLEM OF ARTIFICIAL GRAVITY IN SPACE FLIGHT

Submitted to NASA, Biotechnology and Human Research Division, Office of Advanced Research and Technology, Washington, D. C.

By

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<u>Period Covered</u>

1 July 1968 - 31 December 1968

This report describes the status of NASA Order No. R-93 in the period 1 July through 31 December 1968. During this period, ten reports have been completed, bringing the total under this project to 172.

The majority of the reports dealt with motion sickness, including one which attempted to conceptualize the central nervous system events and processes underlying this curious functional disorder. What goes on in the "Great Intermediate Net" between the vestibular inputs (stimulus from the artificial force environment) and the behavioral manifestations is so complex and hidden from view that only its general characteristics can be inferred from systematic probings. Even these cannot be set forth in a few sentences, partly because it involves the use of new or unusual terms. Although the original account must be consulted for details,the operational relevance can readily be made clear.

In our first major experiment four elite subjects (aviators) had not regained their original state of fitness after 12 days in a room rotating at 10 rpm. Today, within 12 hours we can have subjects rotating at 10 rpm without their ever having any overt symptoms of motion sickness. Tomorrow we hope to reduce the "penalty" (active head motions) which must be paid to effect adaptation. We are proceeding with confidence because we have learned enough about the central nervous system mechanisms to manipulate them within their "safe" range, thus avoiding failure of vestibular homeostasis which is the precipitating factor. When it is realized that 4 to 6 rpm may suffice to generate artificial gravity by rotating a spacecraft and that these terminal velocities are far less stressful than 10 rpm, the feasibility of preventing motion sickness seems to be assured.

There are problems still requiring solution, but a once-feared event, namely, the return to a stationary environment after adaptation at terminal velocity, has been solved through autonomic central nervous system mechanisms. We would have predicted that the more complete the adaptation at a given angular velocity, the greater the severity of symptoms on cessation of rotation. The evidence so far indicates that the opposite is true. It is by means of "over adaptation" at terminal velocity that symptoms became trivial or nil on cessation of rotation.

From the holistic approach to problems in a rotating environment consideration must be given to all manifestations and not just to motion sickness. These fall into two additional categories, one mainly of vestibular origin and the other, ataxia; the latter is largely nonvestibular in origin.

With regard to symptoms of vestibular origin, which can be prevented during rotation just as in the case of motion sickness, the indications are, however, that symptoms will be re-experienced on return to the stationary environment. Systematic studies are in progress, but it is unlikely that present indications are false. This problem is not very serious, and one easy solution will involve making head motions at zero velocity by means of counterrotations in a rotating chair. The problem of ataxia is important,and the solution through manipulation of the force environment is possible but not so simple from the operational standpoint as in the case of motion sickness.

The information being gathered has important theoretical implications which have been reported in the scientific literature. Finally, at least one procedure may have an important place in therapy, and this will be probed.

A highlight of the period under review was the fourth symposium on the role of the vestibular organs in space exploration which was held at Pensacola September 24 to 26. The presentations fell into two specific and one general category. The topic of motion sickness was covered by such notable authorities as Sjöberg, McNally, Borison, and Wendt as well as by present-generation workers. It was clearly evident that although important progress is being made, great effort is required to extract the secrets from the central nervous system.

An impressive list of speakers discussed various components of the vestibular systems, pathways in the central nervous system, sites of interaction between vestibular and other sensory inputs, and events in the cerebellum which involve vestibular activity. One cannot fail but be impressed with the high level of talented investigators devoting their time to elucidating events and processes in specific regional or functional areas. Here too progress is made with difficulty, but in this relatively wide-open field the rewards are rich. It is gradually becoming evident that the vestibular nuclei have important functions as well as serving as relay stations. Who would have thought a short time ago that the rapid eye movements in sleep might have their genesis in the vestibular nuclei; that the cortical projections are extensive, and that interactions in the cerebellar cortex are so rich and meaningful?

The last two of ten sessions dealt with vestibular modelling, artificial gravity, and ataxia (simulated lunar walking), and a precise evaluation of the effects of noise on the acoustic portion of the labyrinth.

STAFFING

Dr. James T. Reason arrived July 5 on a year's leave of absence from the University of Leicester. He is working on the prevention of motion sickness in the Slow Rotation Room by manipulating the adaptive process.

FACILITIES

The equipment used in connection with the preventative or remedial effects of different subgravity levels on cardiovascular and musculoskeletal deconditioning is being upgraded in preparation for a major experiment in the near future.

Completed Reports

*163. Graybiel, A., and Wood, C. D., Rapid vestibular adaptation in a rotating environment by means of controlled head movements.

164. Graybiel, A., Contributions of the space program to our knowledge of motion sickness.

165. Guedry, F. E., Jr., Conflicting sensory orientation cues as a factor in motion sickness.

166. Graybiel, A., and Miller, E. F., II, The otolith organs as a primary etiological factor in motion sickness

167. Miller, E. F., II, and Graybiel, A., The semicircular canals as a primary etiological factor in motion sickness.

168. Graybiel, A., Prevention of motion sickness in the Slow Rotation Room by incremental increases in strength of stimulus.

169. Wood, C. D., Use of drugs in the prevention of motion sickness.

170. Graybiel, A., Structural elements in the concept of motion sickness.

171. Miller, E. F., II, Graybiel, A., Kellogg, R. S., and O'Donnell, R., Motion sickness susceptibility without normal Earth gravitation.

172. Graybiel, A., Kennedy, R. S., and Kellogg, R. S., Motion sickness precipitated in the weightless phase of parabolic flight by Coriolis accelerations.

*Serial numbers.

Funds available on 1 July 1968	$ 122,910.35

Expenditures (1 July through 31 December 1968)

Plant Property Class III	3,071.90
Printing and Publication	975.17
Salaries	70,440.31
Veterinary Supplies	496.26
Contractual Services	5,195.98
Travel	1,568.06*
Books	72.36
Supplies	12,873.93
Electronic Supplies	1,943.71
Photo Supplies	5.70
Total Expenditures	$ 96,643.38

*All travel funds used in connection with human experiments conducted at Langley Research Center and intensive linear acceleration animal experiments at the Space Defense Corporation, Detroit, Michigan.